Thermal Energy Chapter 12

Define:
Temperature, Thermal Energy, Heat, ºC, Kelvin, Absolute Zero, Specific Heat Capacity, Latent Heat

Explain How:
1. I got the balloon inside the Erlenmeyer flask.
2. The drinking duck works.
3. A refrigerator works.

Temperature, T, is a measure of how hot or cold something is.
- Technical definition: the average kinetic energy of the particles (atoms or molecules) that make up a substance.

ºC is degree Celsius, is a unit for measuring temperature based on the boiling point, 100ºC, and the freezing point, zero Celsius, of pure water at standard pressure. (higher pressure lowers the melting point and boiling point)
Pressure is Force/area.

Kelvin - based on the Celsius scale for divisions (difference between boiling and freezing of water

is 100 Kelvin) and absolute zero is zero Kelvin.

Absolute Zero - When the particles have zero kinetic energy - not moving.
absolute zero is at zero Kelvin or -273ºC

What is 22ºC in Kelvin? 295Kelvin = 22ºC
all you do is add/subtract 273

Thermal Energy, U
The sum of kinetic and potential energies of all the particles that make up an object.
Hard to work with because there are so many particles. Temperature is easier.

Heat, Q
The energy that flows due to a difference in temperature. If you put ice in hot coffee, energy goes from the coffee (cools down) into the ice (melts and warms up) until they are at the same temperature (thermal equilibrium, T_E).

Specific Heat Capacity, c
Mental field trip - Tropical Island
sand is very hot in the sun but the water is cool
at night, the sand gets cool but the water stays the same temperature as the day.
Why?
The energy required to change the temperature of

an object is related to the mass (ocean has lots of mass) and the material (specific heat capacity. specific heat capacity, c, is the energy per unit mass to change the temperature by one unit.

find these in a table p248, determined experimentally (next Thursday, labbook)
water, c=4180J/kgºC while for sand it is about 500J/kgºC

eg. You put 500 g of water and 500g of sand on a hotplate and measure the temperature over time. After a few minutes, 6000 J of heat are transferred to each sample. If they both start at 20ºC, what is their final temperatures?

$Q=mc\Delta T$
Q is heat, in joules.
m is mass, in kg.
c is specific heat capacity, in J/kgºC
ΔT is change in temperature, Tf-Ti, in ºC or K.

p247Q1-8
$Q=mc\Delta T$ = 0.50kg 4180J/kgºC (Tf-20º)=6000J
Tf = 6000/(0.5x4180)=2.8708 +20
Tf = 23ºC for water

Sand
6000/(0.5x500)=24 +20

Tf=44ºC for sand

Why is there such a difference in heat capacities?
Think about "average".

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1. I got the balloon inside the Erlenmeyer flask.
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Thermal Energy, U - Sum of all kinetic and potential energies of the particles (atoms and molecules) that make up an object.

Temperature, T: How hot or cold something is. Temperature is the average kinetic energy of the particles.

eg if you have 3 particles with kinetic energies of 2 units, 4 units and 6 units, with no potential energy
U= 12 units of energy
T= (2+4+6)/3=4 units
if I added one more particle with 4 units of kinetic energy, the thermal energy would be U=12+4= 16units but T=4 units again.

We don't measure temperature in joules, we use Celsius - based on pure water freezing at 0ºC and boiling at 100ºC at standard pressure. (pressure is force over area) High pressure lowers the melting and boiling point of water.

Kelvin - based on Celsius scale (same divisions) but zero kelvin is absolute zero - particles have zero kinetic energy at -273ºC.

Convert from Kelvin to Celsius, just add 273ºC.
eg. 22ºC is 295K

Heat, Q
Energy that flows as a result of a difference in temperature.
eg. if you put ice in your hot coffee, energy flows from the coffee into the ice until the ice melts and warms to the same temperature as the cooled coffee. This is called the equilibrium temperature,

T_E basically just means the same temperature.

Specific Heat Capacity, c
Mental Field Trip: Tropical island - sand is hot in the day and cool at night while the water is about the same temperature.
Why?
Sun give heat to both water and sand, but
the ocean has a large mass to warm.
the specific heat capacity - if you give the same heat to the same mass of water/sand the temperature changes differently.

table of values on p248 in textbook

water = 4180 J/kg^{o}C specific heat capacity, c
sand is about 500 J/kg^{o}C for c

eg. you put 500 g of water and 500g of sand on a hotplate for a few minutes and give them both 6000J of energy. If they start at 21 ^{o} what will be their final temperature?

p247 Q1-8 read ahead

heat capacity is the heat required to warm 1kg of a substance by 1^{o}C

$c=Q/(m\Delta T)$

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$Q = mc\Delta T$

Q is heat added/taken away in Joules, J.

m is mass in kg

c is specific heat capacity, in J/kg°C (find on p248)

ΔT change in temperature, Tf-Ti, in °C.

Water

Q=mc(Tf-Ti)

6000J = 0.50 kg 4180 J/kg°C (Tf - 21°C)

Tf = (6000/(0.5x4180))+21=23.8708

Tf=24°C

Sand

Q=mc(Tf-Ti)

6000J = 0.50 kg 500 J/kg°C (Tf - 21°C)

Tf = (6000/(0.5x500))+21=45

Tf = 45°C

p247 Q1-8

Read lab for next Thursday p34 in labbook